Title of the Invention -

The Automatic Furnace -

System and method for

automatically maintaining

a multiburner furnace.

Inventor - Adolph Mondry

25406 Goddard Road

Taylor, Michigan, 48180

(313) 291-5550

Citizenship – United States of America

1

CROSS REFERENCES TO RELATED APPLICATIONS

001 Adolph Mondry – System and method for automatically maintaining a

blood oxygenation level. P.N. 5,682,877, November 4, 1997 – herein

referred to as 877. The flow charts of that device are similar to those of the

Voltage Dosimeter.

002 Adolph Mondry – The Voltage Dosimeter – System and method for

supplying variable voltage to an electric circuit. P. N. application number

not yet available. The flow charts of that device are identical to that of the

Automatic Furnace.

003 Lawrence E Bolo et al – Combustion in a multiburner furnace with

selective oxygen flow. P.N. application Kind Code A1 20030091948, May

15, 2003. Describes multiburner furnace technology.

FEDERALLY SPONSORED RESEARCH GRANTS

004 There are no Federally sponsored research grants available to those

involved in the research and development of this device.

BACKGROUND OF THIS INVENTION

005 Multiburner Furnaces provide heat and energy. With recent

improvements in furnace design the ratio of combustants to oxidants yield

lower levels of flue carbon monoxide (CO) in a less fuel rich burn,

producing less ash and greater efficiency; less flue nitrogen monoxide (NO)

in a less fuel lean burn, producing less pollution; and, flue temperature

balancing CO and NO. Day to day use may undo these improvements at a cost. It is desirable to have a device available, which automatically controls and prolongs these improvements.

## BRIEF SUMMARY OF THE INVENTION

006 It is an object of the present invention to provide a method and apparatus to control CO, NO, or temperature in the flue of a multiburner furnace to produce and deliver appropriate oxidants to the combustants at the burners to increase efficiency and decrease pollution. It is a further object of this invention to provide a device which will prolong all improvements.

007 In carrying out the above objects and other stated objects and features of the present invention a method and apparatus is provided as an Automatic Furnace for maintaining a desired CO, NO, or temperature range at the flue (referred to as flue parameters) of a multiburner furnace. and includes delivering a first oxidant (oxygen or air) dose to the combustant/oxidants at the burners of a multiburner furnace of any design producing a sequential flue parameter dose selected from one of a plurality of sequential flue parameter doses between a first flue parameter dose and a second flue parameter dose. The method includes delivering a second oxidant dosage to the burner while repeatedly sequencing through the plurality of sequential flue parameter doses beginning with the first flue parameter dose and proceeding to an adjacent flue parameter dose in the

3

sequence after a predetermined time interval has elapsed. The second

oxidant dosage is delivered until the flue parameter level attains the

desirable range, at which point corresponding oxidant doses and flue

parameter doses are selected from the plurality of oxidant doses and the

plurality of sequential flue parameter doses. The method also includes

delivering the selected oxidant dose and flue parameter dose so as to

maintain the desired flue parameter range.

008 In the preferred embodiment the method and apparatus employs CO as

the sole flue parameter. The other flue parameters may be employed as well.

009 The advantages of the Automatic Furnace are minimal needs for

furnace shut downs, less pollution, more efficiency, and a reduction in the

cost of running and maintaining a multiburner furnace.

010 The above objects, features, and other advantages will be readily

appreciated by one of ordinary skill in the art from the following detailed

description of the best mode for carrying out the invention, when taken in

connection with the accompanying drawings.

BRIEF DESCRIPTION OF THE DRAWINGS

011 Fig. **1/6** demonstrates a perspective view of the first embodiment of

the present invention.

012 Fig. **2/6** is a graphical demonstration of the flow charts of the

Automatic Furnace.

4

013 Fig. **3/3-5/6** are flow charts dealing with the oxidant dosage and CO

dosage strategy of the present invention for use in the Automatic Furnace.

014 Fig. **6/6** is a flow chart for relating parameters in the Automatic

Furnace.

## DETAILED DESCRIPTION OF THE INVENTION

015 Referring now to Fig. **1/6**, a first embodiment of the present invention

is shown. This embodiment indicated by reference number **1** in Fig. **1/6** is

the best mode in implementing this invention and is particularly suited for

use as an Automatic Furnace. Figure **1/6** includes **2,** multiburners; **3,**

combustants (solid, liquid, or gas): **4,** oxidants (oxygen or air); **5,** a furnace

flue; **6,** a multiburner furnace; **7,** a flue parameter sensor in Vol% or degree

Centigrade; **8,** a band pass filter; **9,** the ECU; **10,** multiple variably opening

solenoid valves; and,**11,** the oxidant entrance.

016 In response to flue parameter sensor 7 data, oxidant flow rates at the

inlets **11** are controlled by an ECU **9** controlled variably opening solenoid

valve **10** with Coulomb controlling circuits, as was taught in 877 and United

States P. N. 5,008,773. They enhance or restrict combustion at the

burners **2.**

017 Referring now to Fig. **2/6**, the method of device function is

demonstrated graphically. The flue parameters are placed on the ordinate

and time or oxidant dose are placed on the abscissa of a Cartesian plane.

Maximum oxidant dosage occurs at tr on the abscissa, the significance of which will be presented later. Measured and calculated logarithmic functions are used in the preferred embodiment as flue parameter dosages, but any measured and estimated transcendental function with an inverse may be used.

018 Referring again to Fig. **1/6**, as will be seen, conditions on CO – the preferred flue parameter - control oxidant flow rate **11** and thus CO dosage.

019 Referring now to Fig. **2/6**, the illustrated method of oxidant dosage and CO level selection starts with the administration of an extreme oxidant gas flow rate – herein referred to as the selector dose of the oxidant gas flow rate which produces the maximum or minimum CO dosage – as in curve A or B. Curve A is represented by y=log to the base a of x. Curve A activates at x=0.

020 Line CG is the desired CO level – herein referred to as the selection parameter, which is a range in the actual device. At the intersection of line CG and curve A or B (call it X), line D points to point E on the abscissa as the selected oxidant dose. This is determined by graphical means and, as will be seen, the flow charts. The virtual CO dosage in Vol % is curve F, which activates at point E, the selected oxidant flow rate, and is boosted by curves A, B, H – an overshoot of curve A – and curve I – a deactivation of

curve H – to produce line G, which is the selected CO level, is also a CO dosage, and is represented by $y=\log$ to the base b of tr , where tr is the t value of the flattening out of the logarithm $y=\log$ to the base b of t (curve F) at tr seconds. Line G is completely determined by the intersection (X) described above and in the flow charts, as will be seen, thus the determination of curve F and line G by the above methods is unnecessary. Curve F and line G start in the x coordinate system at x=t and in the t coordinate system at t=0, when curve A deactivates. Curve F and line G deactivate when curve A activates. Curve J is the virtual curve of curves A and H. K marks the Circulation time. It marks the time from the initial oxidant gas flow rate to the first recording of any change in the CO dosage or level. Its accuracy is essential for proper flow chart function with respect to time. Its calculation and that of tr will be demonstrated. The oxidant dose is circulation time dependent. The CO dose is not, since it is a function of time.

021 Before describing the flow charts it is useful to explain the terminology employed. The most recent base state keeps CO in its desirable range. The oxidant flow rate and CO level are measured in all states. The washout state washes out overshoots. It also determines the selected CO dose and oxidant flow rate, as will be seen. CO doses are functions of oxidant flow rates.

022 Referring now to Fig. **3/6-5/6,** flow charts are shown, which illustrate the system and method for the proper selection of oxidant flow rates and CO doses.

023 Referring to Fig. **3/6,** Step **400** determines various system parameters, which may be predetermined and stored in memory, calculated by an ECU (such as ECU **9** in Fig. **1/6**) or entered by a system operator. The system parameters include the following:

MIN R=minimum dose of oxidant flow rate given for each range.

MAX R=maximum dose of oxidant flow rate given for each range.

CO=level in Vol%

TCO1=desired CO level.

dL=low CO level threshold.

dH=high CO level threshold.

Tss=series state delay time.

Tcirc=circulation delay time.

Twash=washout delay time.

tr=desired response time or reaction time

The value of dH and dL are determined by the current operating state.

024 As shown in Figure **3/6** the ECU now passes control to Step **402,** which measures the oxidant flow rate and CO level.. At Step **404** a maximum oxidant dose of the last range is administered. This is

8

represented graphically by curve A of Figure **2/6** and is called the selector

dose. It represents the maximum oxidant dose. The possible CO level is set

for the lowest level of the lowest range.

025 With continuing reference to Figure **3/6** at Step **406** the oxidant dose

is maintained while pausing Tcirc seconds, then x is set to 0 seconds. Step

**406** is called an adjustment state. It coordinates the flow charts with

respect to time. Initial circulation times may be estimated or measured.

026 Referring once again to Figure **3/6** the ECU passes control to Step

**408**, which continues to deliver maximum oxidant dosage to the burners.

Step **408** is referred to as a series state -Tss – and is necessary to

coordinate the progression through various possible CO levels within a

time period determined by tr. The calculation of Tss depends on the

current operating state. Some representative calculations are illustrated in

Figure **6/6** for a single ranged implementation as discussed in greater

detail below.

027 Still referring to Figure **3/6** a test is performed at Steps **409** and **410.**

It asks – is CO greater than dH? – and, is CO less than dL?, respectively.

They split control into three pathways. Negative answers to both

conditions direct control to Step **426**, where 1. The definitive current CO

level is set to the possible level, while the preliminary oxidant dose is set

one circulation time into the future. 2. A pause for the circulation time

takes place. Then, 3. t is set to 0. This represents preliminary oxidant dose and definitive CO dose selection.

028 Now referring to Figure **4/6** processing continues with the ECU directing control to Step **428**, which pauses to washout high valued functions from the selected dose. The state is completed when all involved functions equal a straight line – the selected CO level or dose. For convenience in the representation of the method in the flow charts the ECU was represented to set t=0 in Step **426**. This actually occurs at the start of the washout state. The ECU directs in the washout state the determination of the selected value of point E of Figure **1/6** – the definitive selected oxidant dose – then activates this dose. The CO dose remains the selected dose as line G in Figure **1/6**. Both of the above dosages continue until activation of MIN R or MAX R. Figure **430** measures CO values for the Conditions below. Steps **409** and **410** represent a second test and ask the same questions as the above mentioned first test – Is CO greater than dH or less than dL, respectively? If either answer yes, control is directed to Steps **431** and **434,** respectively, where a predetermined fraction of tr is either subtracted or added, respectively to tr. This pathway determines tr only if the circulation time is correct. The circulation time is calculated by keeping the last three base state values in memory. When control is directed to or beyond a noncontiguous base

state from which control was originally assumed a predetermined amount of time is added to the circulation time. This will correct abnormally short circulation times. For abnormally long circulation times – if control passes consecutively to two ascending or descending base states, a predetermined amount of time is subtracted from the circulation time.

029 Referring now to Figure **5/6,** if both conditions in the second test answer no, the ECU places control in Step **436,** the base state. Steps **438** and **440** represent the third test and ask the same questions (is CO > dH or < dL?) as those of the previous tests with different consequences. They determine the stability of the base state (both conditions answer no if it is stable). If it is unstable, the ECU directs control to either Step **463,** if Step **438** answers yes, or **446,** which 1. Minimizes or maximizes the current dose, respectively 2. Pauses for the circulation time, then 3. Sets x=0. These doses continue until dose selection. It should be noted that Steps **431, 434,** the yes part of **418,** and the no part of Steps **433** and **440** all yield control to Step **436,** the base state. The ECU then directs control from Step **463** to Step **411,** and from Step **446** to Step **412.**

030 Referring again to Figure **3/6,** the ECU directs control from Step **464** (evaluated later), and if Step **414** in Figure **4/6** (the first condition of fourth test to be elucidated soon) answers no, to Step **408** to maintain the current CO dose for Tss. Control is then directed to Step **409,** which, if

along with Step **410** - the first test – the answer is yes to both conditions, control is passed to Steps **411** and **412**, respectively, which decrement and increment the possible dose, respectively, then both pass control to Condition **414**.

031 Referring now to Figure **4/6**, Steps **414** and **418** represent the fourth and final test with different conditions than the other tests. These conditions ask if the present possible dose is the last dose available, and if the present range is the last one available, respectively. If Step **414** answers no, control is directed by the ECU to Step **408** in Figure **3/6**, which maintains a current dose for Tss. If the condition answers yes, control is directed to Step **418**, which determines if the present range is the last range available. If it answers no, control is directed to Step **464,** in which control enters a new range, sets the current oxidant and CO dose to MAX R or MIN R of the new range, pauses for the circulation time, then sets x=0. Control is then directed to Step **408**, which maintains a current oxidant and CO dose for Tss. If Step **418** answers yes, the ECU directs control to Step **436**, the base state.

032 Referring now to Figure **6/6** a flow chart is shown illustrating representative calculations of Tss according to the present invention. One of these calculations or an analogous calculation is performed for each series state of Figure **3/6-5/6**, such as illustrated at Steps **408, 411,** and **412**.

033 Returning to Figure **6/6** at Step **480** a test is performed to determine if the system has reached a base state. If not, the series state delay is estimated as: Tss=tr/IR. If the result is true, the process continues with Step **484**, where a test is performed to determine whether CO<dL. If true, then Step **486** determines whether the most recent base state is a minimum for the current range. If it is true, the series state delay is calculated by Step **488** as Tss=tr/(IR-1). Step **498** then returns control to the series state which initiated the calculation.

034 With continuing reference to Figure **6/6,** if the test at Step **486** is false, then the series state delay is calculated by Step **490** as Tss=tr(MAX R-MIN R)/(IR-1)(MAX R-BASE STATE) before control is released to the series state via Step **498.** If the test performed at Step **484** is false, then Step **492** performs a test to determine if the most recent base state is the maximum for the current range. If the result of Step **492** is true, then Step **496** calculates the series state delay as Tss=tr/(IR-1). Control is then returned to the appropriate series state via Step **498.** If the result of the test at Step **492** is false, then the series state delay is calculated by Step **494** as Tss=tr(MAX R-MIN R)/(IR-1)(BASE STATE-MIN R). Step **498** then returns control to the appropriate series state. Figure **6/6** applies to a single range. One of ordinary skill in the art should appreciate that the calculations may be modified to accommodate a number of possible ranges.